Draft: Comments Welcome

Title:

A Structural Approach to Price Transmission in Non-Competitive Market Channels: A Study of the Fluid Milk Market

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Abstract: We estimate cost pass through rates (CPTR) in the Boston fluid milk market while taking into account strategic conduct between retailers and processors. By using structural demand and supply specification we estimate and test for the pass through rates at different stages of fluid milk marketing channels, and for firm specific as well as industry wide cost shocks. The former are useful for analyzing whether firm specific cost changes due to a merger or leveraged recapitalization are passed forward to consumers. We find that the pass through rates for industry wide cost shocks such as the change in farm level milk prices are approximately 85%. Firm specific cost shocks, however, have a much lower pass through rate, ranging from 29% to 40%.

Introduction:

Research in agricultural economics on cost pass through rates (CPTR) has concentrated almost exclusively on homogeneous products and models that assume the market channel is a single industry of competitive firms (e.g. Gardner 1975, Heien 1980, Kinnucan and Forker 1987). Recently McCorriston et al. (1998) relax the competitive assumption but continue to maintain the single stage (industry) and homogeneous product assumptions. Moreover, rather than estimate or test their model, McCorriston et al. assumed its validity and used parameter estimates from other sources to estimate CPTR to simulate results for agricultural product industries. Ashenfelter et al. (1998) working on the Staples-Office Depot merger case have estimated firm specific cost shocks using a reduced form estimation procedure that is an adaptation of the Baker and Bresnahan residual demand approach to the measurement of market power (1985, 1988). That study also focuses on a marketing channel with only one stage. In this paper we develop a structural specification for the two stages in the fluid milk marketing channel, processing and distribution, and we estimate CPTRs for individual firms in a differentiated product oligopoly at each stage of the marketing channel. Our structural approach is able to measure CPTRs for firm specific as well as industry wide cost shocks.

This paper uses Information Resources Inc. (IRI) - Infoscan database for fluid milk products for each of the top four supermarket chains in Boston (Stop & Shop, Shaw's, Star Market and DeMoulas). The data are monthly from March 1996 to July 1998. This period includes the dramatic increase in farm level fluid milk price due to the advent of the Northeast Dairy Compact (NEDC). For this reason we are particularly interested in how each chain and fluid milk processors change fluid milk prices when farm level fluid milk price, an industry wide cost shift variable, changes.

Cost Pass-Through Models for Differentiated Product Oligopoly:

The Ashenfelter et al. (1998) partial equilibrium model analyzes two types of cost shocks – industry wide and firm specific and does so only in a residual demand framework that does not identify strategic interaction (reactions) among firms. In this paper we advance the theory and empirical analysis by introducing a more disaggregate structural model that identifies cross firm price shocks and corresponding pass through rates as well as industry and firm specific rates. Given an oligopolistic market structure, a firm specific shock not only influences that firm's own price level; it also causes other firms to react to that price and change their prices (Cotterill 1994, 1998, Cotterill et al. 2000).

Our structural model specification also allows us to specify alternative conduct games and test to determine which best replicates observed market conduct. This detail is not possible in the Ashenfelter et al. residual demand approach. Also all literature on price transmission in agricultural economics has only considered industry wide cost shocks and, except for McCorriston et al. they do time series analysis of farm and retail prices, which is at best an unknown approximation to a reduced form model of the food marketing channel.

Here we specify horizontal competition both at the processing and retail level as Nash in prices. We assume Bertrand price competition exists among retailers. To capture the vertical nature of competition between processors and retailers, we specify three different games: supermarkets with upstream integration (complete vertical coordination game), a vertical Nash model where each supermarket chooses an exclusive processor and processors and retailers maximize profit simultaneously by deciding on the wholesale and retail price, and a vertical Stackelberg game where in the first stage a retailer decides on the profit maximizing price and then a processor maximizes profit taking into account the reaction function of the retailer.

Our work to date assumes vertical dyadic relationships between processors and retailers, i.e. each retailer deals with one exclusive processor of milk. This is clearly not the case and is a shortcoming. Consequently we do not analyze horizontal competition between processors. Other researchers on vertical structural models have the same constraint as in Kadiyali et al. 1996, 1998. In future research we plan to allow for more processor interactions via vertical competition for customers by disaggregating the commodity "milk" into branded and private label milk. One could continue such disaggregation to the brand level. Then the model would be more disaggregate than the typical firm since a brand of milk is supplied to more than one retailer. In these disaggregate models, modeling competition among processors as a vertical game through retailers rather than a direct horizontal game among processors at the wholesale level seems sufficient and reasonable. Processors compete with each other through retailers in the retail market for the sale of their products.

Channel Models:

For simplicity of exposition we present a two retailer two processor model. In the empirical section of this paper we extend the model to four retailers and four processors.

In all the three games, we assume a Bertrand pricing game at the retail and processor level. Let the demand functions of the retailers be the following:

$$q_1 = a_0 + a_1 p_1 + a_2 p_2$$
$$q_2 = b_0 + b_1 p_1 + b_2 p_2 \qquad [1(a)-(b)]$$

Processor level demand is derived from the retail level demand specifications given retail conduct and margin. To derive these processor level demand functions different conjectures are assumed at the processor level concerning retailer reactions. These conjectures can be perceived as assumptions by the processors about retailer pricing behavior given a wholesale price. For the vertical integration (full coordination) game we need no vertical conjecture assumptions because the channel has only one industry – integrated retailers.

Let the retailer’s cost function be the following:

$$TC_1 = w_1 * q_1$$
$$TC_2 = w_2 * q_2 \qquad [2(a)-(b)]$$

where: w_1 and w_2 are the wholesale prices received by the processors.

So, the retailers’ profit functions can be written as :

$$\Pi_1^R = (p_1 - w_1)q_1$$
$$\Pi_2^R = (p_2 - w_2)q_2 \qquad [3(a)-(b)]$$

Following Choi (1991), in the Vertical Nash game, a linear mark-up at retail is conjectured by the processor on retail price; so, retail price can be written as:

$$p_1 = w_1 + r_1$$
$$p_2 = w_2 + r_2 \qquad [4(a)-(b)]$$

where: r_1 and r_2 are the linear mark-up at the retail level.

In the Stackelberg game, each processor develops a conjecture from the first order condition of the retailer. The retailer's first order conditions are:

$$
\begin{aligned}
p_1 &= \frac{1}{2}w_1 - a_0 - a_2 p_2 \\
p_2 &= \frac{1}{2}w_2 - b_0 - b_1 p_1
\end{aligned}
\qquad [5(a)\text{-}(b)]
$$

We assume that each manufacturer only knows its own retailer's reaction function and that the manufacturer ignores impacts of its wholesale price change on the other retail price. The resulting Stackelberg conjectures are: $\left.\frac{\partial p_1}{\partial w_1}\right|_{Conjecture} = \frac{1}{2}$ and $\left.\frac{\partial p_2}{\partial w_2}\right|_{Conjecture} = \frac{1}{2}$. In fact once we have the estimated CPTRs from the full model we can test to see if the observed derivatives are equal to one half. Testing the estimated CPTRs against the original conjectures for vertical Nash (1) and manufacturer Stackelberg (1/2) gives us information on the most appropriate game.

We simplify the processor level marginal cost function in the following manner:

$$
\begin{aligned}
wmc_1 &= m + m_1 \\
wmc_2 &= m + m_2
\end{aligned}
\qquad [6(a)\text{-}(b)]
$$

where: m is the industry specific marginal cost component and m_1 and m_2 are the processor specific cost components.

So, the processors profit functions can be written as:

$$
\begin{aligned}
\Pi_1^P &= (w_1 - m - m_1)q_1 \\
\Pi_2^P &= (w_2 - m - m_2)q_2
\end{aligned}
\qquad [7(a)\text{-}(b)]
$$

Using the profit maximizing first order conditions both at the processing and retail level we derive the CPTR equations. They are presented in Table 1a and 1b. Table 1a gives the CPTR to wholesale and from wholesale to retail for the vertical Nash and vertical Stackelberg games. Note that they are only functions of the demand parameters due to the constant marginal cost assumption. Slade (1995), Choi (1991), Cotterill et al. (2000) and others have modeled vertical interaction by assuming that retail sales are made by a monopolist that is supplied by more than one manufacturer. Here we assume the converse (multiple retailers each supplied by a single manufacturer). If in fact our retailers are monopolists then the transmission rates for changes in processor's marginal costs to the wholesale price are 2/3 for vertical Nash and 1/2 for manufacturer Stackelberg. In addition to determining whether the cross price coefficients in a demand model are zero we can also test for retail monopoly by testing whether estimated CPTR are equal to these values.

For the CPTR between wholesale and retail prices, if we have retail monopolies the rates for both the vertical Nash and Stackelberg game reduce to1/2. Again we can test for this condition.

Returning to the general formulae in Table-1a if the following regularity conditions: $a_1 > a_2 \;\; b_2 > b_1$ hold for the demand equations (Choi 1991, Jeuland and Shugun 1988) then all CPTR are bounded between 0 and 1. Therefore even for an industry wide cost shock in a duopoly and more generally an oligopoly, we would not expect to see 100% CPTR. Note also the pass through rates for cross price shocks. For example if the cross pass through rate $\frac{dw_1}{dm_2} = 0$ then the industry wide CPTR, $\frac{dw_1}{dm}$ equals the firm specific CPTR $\frac{dw_1}{dm_1}$. If the cross pass through shock is positive then the firm specific CPTR is always less than the industry wide CPTR. Finally if the processor industry is effectively competitive we would expect $\frac{dw_1}{dm_1}$ and $\frac{dw_2}{dm_1}$ to be zero. Changes in firm specific marginal cost could not or would not be passed on. Thus if firm specific CPTR are not zero we have an affirmative test for market power.

Given the derivations in Table-1a the following total CPTR relationships hold:

- In the case of industry wide shocks:

$$\frac{dp_1}{dm} = \left(\left.\frac{dp_1}{dw_1}\right|_{dw_2=0} * \left.\frac{dw_1}{dm}\right|_{dm_1=dm_2=0} \right) + \left(\left.\frac{dp_1}{dw_2}\right|_{dw_1=0} * \left.\frac{dw_2}{dm}\right|_{dm_1=dm_2=0} \right)$$

$$\frac{dp_2}{dm} = \left(\left.\frac{dp_2}{dw_1}\right|_{dw_2=0} * \left.\frac{dw_1}{dm}\right|_{dm_1=dm_2=0} \right) + \left(\left.\frac{dp_2}{dw_2}\right|_{dw_1=0} * \left.\frac{dw_2}{dm}\right|_{dm_1=dm_2=0} \right) \qquad [8 (a)-(b)]$$

➢ Similarly, for channel specific shocks:

$$\frac{dp_1}{dm_1} = \left(\left.\frac{dp_1}{dw_1}\right|_{dw_2=0} * \left.\frac{dw_1}{dm_1}\right|_{dm=dm_2=0} \right) + \left(\left.\frac{dp_1}{dw_2}\right|_{dw_1=0} * \left.\frac{dw_2}{dm_1}\right|_{dm=dm_2=0} \right)$$
$$\frac{dp_2}{dm_1} = \left(\left.\frac{dp_2}{dw_1}\right|_{dw_2=0} * \left.\frac{dw_1}{dm_1}\right|_{dm=dm_2=0} \right) + \left(\left.\frac{dp_2}{dw_2}\right|_{dw_1=0} * \left.\frac{dw_2}{dm_1}\right|_{dm=dm_2=0} \right) \qquad [9(a)\text{-}(b)]$$

$$\frac{dp_1}{dm_2} = \left(\left.\frac{dp_1}{dw_1}\right|_{dw_2=0} * \left.\frac{dw_1}{dm_2}\right|_{dm=dm_1=0} \right) + \left(\left.\frac{dp_1}{dw_2}\right|_{dw_1=0} * \left.\frac{dw_2}{dm_2}\right|_{dm=dm_1=0} \right)$$
$$\frac{dp_2}{dm_2} = \left(\left.\frac{dp_2}{dw_1}\right|_{dw_2=0} * \left.\frac{dw_1}{dm_2}\right|_{dm=dm_1=0} \right) + \left(\left.\frac{dp_2}{dw_2}\right|_{dw_1=0} * \left.\frac{dw_2}{dm_2}\right|_{dm=dm_1=0} \right) \qquad [10(a)\text{-}(b)]$$

Table-1b gives the formulae for the total CPTR and their values if we observe retail monopolies. Again one can use CPTR to test for retail monopolies and non-zero cross price shocks also drive a wedge between industry and firm specific CPTR. Table-1b also gives the CPTR for the integrated or fully coordinated (perfect vertical tacit collusion) game. Note that when one eliminate the double margnialization that occurs in the vertical Nash and Stackelberg games the pass through rates, in the retail monopoly case, increase to 1/2. The same is true for the more general case, i.e. full coordination reduces double marginalization and increases the CPTR.

Also note that in Table1a-b that $\frac{dw_1}{dm_1} = \frac{dw_2}{dm_2}$, $\frac{dp_1}{dw_1} = \frac{dp_2}{dw_2}$ and $\frac{dp_1}{dm_1} = \frac{dp_2}{dm_2}$ in this two-person game, however this is unique to the two processor-two retailer vertical dyadic game. In a game with more than two players they will not be equal.

Variable Definitions and Model Specification:

We use IRI scanner data that include monthly quantities sold, average price per gallon, average package size sold, for the four leading retail chains (Stop & Shop, Shaw's, Star Market, and DeMoulas) in the Boston market. The fluid milk category covers disappearance of skim/low fat and whole milk within a retail chain. In the present model, farm level fluid milk price will be taken as exogenous. We use Announced

Cooperative Class – I milk pay price for the farm level milk price series. Since the Federal Milk Marketing Order sets the farm level (class-I) prices for Boston, based on national manufacturing milk prices and a differential set in the 1995 farm law, the assumption that the farm level fluid prices for Boston are exogenous is not unrealistic. Demand for fluid milk in Boston does not appreciably affect the national supply-demand system for manufacturing milk upon which the New England farm level fluid price is based.

To identify the demand side we specify weighted average percentage price reduction, a measure of trade promotion activity, for each retailer in each demand equation. To identify the supply side we specify the measure of volume per unit, for each retail chain. Variation in average volume per unit (e.g. shifting from 0.25 to 1 gallons per unit sold), captures exogenous cost components related to package size; so, we use it as a supply side variable.

Empirical Estimation Procedure:

To estimate our models, we use the fluid milk demand equations for retailers and the appropriate first order conditions. We specify linear demand function for the convenience of estimation and tractability. We use the following set of demand equations:

$$\begin{aligned} q_{SS} &= i_1 + a_1 p_{SS} + a_2 p_{Sh} + a_3 p_{SM} + a_4 p_D + \vartheta_{SS} WRR_{SS} \\ q_{Sh} &= i_2 + b_1 p_{SS} + b_2 p_{Sh} + b_3 p_{SM} + b_4 p_D + \vartheta_{Sh} WRR_{Sh} \\ q_{SM} &= i_3 + c_1 p_{SS} + c_2 p_{Sh} + c_3 p_{SM} + c_4 p_D + \vartheta_{SM} WRR_{SM} \\ q_D &= i_4 + d_1 p_{SS} + d_2 p_{Sh} + d_3 p_{SM} + d_4 p_D + \vartheta_D WRR_D \end{aligned} \qquad [11(a)\text{-}(d)]$$

where, q and p are quantity and price variables; and the subscript SS – Stop & Shop, Sh – Shaw's, SM – Star Market and D – DeMoulas. We close the model with the following linear marginal/average cost function:

$$mc_i = m + m_i + \eta_i VPU_i \qquad [12]$$

where, m is the price of raw milk, $m_i (i = SS, Sh, SM, D)$ are the firm specific unobserved (to the econometrician) cost component and VPU_i (volume per unit) captures the cost component related to packaging. The unobserved cost component will be estimated within the system.

For our vertical Nash and Stackelberg model, we have two profit functions that need to be maximized. For the full Coordination game, the two profit functions become one for the vertically integrated firm.

At the retail level we have the following profit function:

$$\pi_i^R = \left(p_i - w_i\right) * q_i \qquad [13]$$

and at the processor level:

$$\pi_i^P = (w_i - mc_i) * q_i \qquad [14]$$

By manipulating the first order conditions derived from the two profit functions we obtain the following estimable first order conditions:

$$\begin{aligned} p_{SS} &= m + m_{SS} + \eta_{SS} VPU_{SS} - \left(k / a_1 \right) q_{SS} \\ p_{Sh} &= m + m_{Sh} + \eta_{Sh} VPU_{Sh} - \left(k / b_2 \right) q_{Sh} \\ p_{SM} &= m + m_{SM} + \eta_{SM} VPU_{SM} - \left(k / c_3 \right) q_{SM} \\ p_{D} &= m + m_{SS} + \eta_{D} VPU_{D} - \left(k / d_4 \right) q_{D} \end{aligned} \qquad [15]$$

Here, when k = 1, then the first order conditions will represent the full coordination game, k = 2 represents first order conditions from vertical Nash game, and k = 3 represents the manufacturer Stackelberg game.

These four first order conditions with k = 1,2 or 3 and the four demand equations are the models that we estimate with non-linear 3SLS regression using SHAZAM (ver. 8). After estimating all three models we use a classical likelihood ratio test as described in Vuong (1989) to determine the best fitting model.

Estimation Results:

Graph-I shows the fluid milk price for the four retailers and the announced co-op milk (farm level) price for Boston within our period of study. We certainly do see variation in these prices over time. Star Market the urban as opposed to suburban supermarket chain consistently has the highest milk prices. DeMoulas consistently has the lowest prices. Stop & Shop and Shaw’s are at the same price level until March 1997 when Shaw’s embarks on a consistently lower price targeting then Stop & Shop. The price gap between the leader (Stop & Shop) and the maverick (Shaw's) widens appreciably during the North East Dairy Compact price stabilization period.

The impact of the North East Dairy Compact is clearly visible in June 1997 when it increased the farm level milk price to $1.46/Gallon, and the fluid milk price is pegged at that level for the rest of the sample period. Note that the most variation in the farm milk price series occurs around the short supply situation in the Fall of 1996 and the subsequent supply response around January 1997.

This rather unique farm level milk price series allows us to decompose strategic price conduct by the four supermarket chains. In Graph-I, first note that when the farm level milk price increased at a slow trend rate prior to December 1996, retail prices remained essentially flat. When farm milk prices plummeted in 1997 retail prices also remained flat, i.e. unresponsive. Only when the announced, and well publicized in advance, North East Dairy Compact price stabilization took place in July 1997 did the retail prices respond to change in the farm prices. The first differences in Graph-2, also documents that there is no readily discernible transmission of farm price changes except for the July 1997 move.

Table-2 presents price data just immediately before and after the North East Dairy Compact stabilization move. The NEDC increased price $0.10/gallon from $1.36/gallon. Note that three of the retailers increased retail price $0.14/gallon, a 140% CPTR and the other increased price $0.16/gallon a 160% CPTR.

Retailers clearly used the well publicized implementation of the North East Dairy Compact to jointly raise retail milk prices in excess of the farm level price increases. In conjunction with no, or at best partial, transmission of the much larger farm level price decrease in late 1996 does suggest asymmetric price transmission and the exertion of market power in periods of farm level disequilibrium, especially when a move to new equilibrium is a well publicized in advance due to public policy. This response pattern can be explained by the focal point theorem (Schelling, 1960). Chua (1998) finds the same type of price response pattern in the beer industry. The retail price of beer shot up more than proportionately for all the major brands when federal sales tax on beer was increased significantly.

By another measure the processors and retailers response to the farm price change was even more dramatic. The average retail price farm cost spread prior to the North East Dairy Compact move for Stop & Shop was \$ 0.978. After the North East dairy Compact move it widened to \$ 1.21. For Shaw's prior to North East Dairy Compact it was \$ 0.957. After it widened to \$ 1.13. For Star Market it changed from \$ 1.11 to \$ 1.35. For DeMoulas it went from \$ 0.746 to \$ 0.956. Thus consumer prices increased when the North East Dairy Compact stabilized the price roughly at the full period sample average because the farm retail price spread went up around \$0.20. Price theory predicts that reducing input price risk should allow firms to lower margins but instead they increased in this market.

Note in Graph-II that Stop & Shop, the market leader with 28% supermarket sales in the Boston metro area in 1999 (Progressive Grocer – 2000 Market Scope, page 313) has the most stable prices after the July 1998 price hike. Shaw's, a firm recently acquired by Sainsbury PLC that is committed to aggressive expansion in New England is a distinct number two firm in Boston with a 16.7% market share (Progressive Grocer – 2000 Market Scope, page 313). Graph – II clearly shows that Shaw's is the price maverick firm most willing to cut price and defect from the price leadership of Stop & Shop. Star Market (12.7% market share) and DeMoulas (12.3% market share), firms with shares not much smaller than Shaw's more clearly follow Stop & Shop's price leadership.

Proceeding to estimation, the vertical Nash, vertical Stackelberg and full coordination models were estimated using non-linear 3SLS. To select the appropriate model we use the likelihood test statistic as in Vuong (1989). Table 3 presents the test statistics. None of the test statistics is significant at 5% level. However following Gasmi and Vuong (1989), the signs of the test statistic give us a weak idea of the appropriateness of model over other models. For example the negative sign of the test statistic for the comparison between vertical Nash and Stackelberg suggests that the Stackelberg model is more appropriate than Nash; and the negative sign for coordination vs. Stackelberg also suggests Stackelberg is preferred. Vertical Nash is preferred to coordination.

A second test for the appropriate model is to compare the estimated wholesale price to retail price CPTRs against the assumed conjectures in each model. The

Stackelberg model clearly performs best by this criterion. We assumed that the CPTR from wholesale to retail was 0.5 and our estimates are close to 0.5. Only in 2 of the 4 cases are they significantly different from 0.5 at the 5 % level and those estimated are still below 0.6 (see Table 6 second column). Therefore we will focus on the Stackelberg results in the text. The results for the other two models are presented in the appendix.

Table-4 presents the descriptive statistics of the variables used in the analysis. Table-5 presents the regression results for Stackelberg game. We have negative and significant own price demand coefficients for all the chains. In the Stop & Shop demand equation only Shaw's is a significant substitute. Increases (decreases) in Shaw's prices, which we saw earlier are quite volatile during the latter half of this period, lead to decreases (increases) in Stop & Shop's quantity sold. In the Shaw's demand equation only DeMoulas is a significant substitute. Note that Stop & Shop prices have no significant effect on Shaw's quantity sold. In the Star Market demand equation all of the other three chains are significant substitutes. Star Market with its older, smaller urban core stores is clearly severely impacted by any price competition (price decreases) and thus is most willing to follow any price elevation game initiated by another firm. DeMoulas , on the other hand, is only effected by price changes from Shaw's. In conclusion, from the demand side of this market the firm that is the price maverick, Shaw's does significantly affect the sales of all other chains in the market.

The estimation results for the cost parameters displayed in Table-5 are robust. Seven of the eight parameters are significant at the 5% or better level and the signs are correct. Since we assumed that 100% of the farm milk price goes to marginal cost we restricted its coefficient to be one in the cost equations.

In table 6 we present the estimated pass-through rates and assorted statistical tests for the Stackelberg game. The first column give the industry wide farm milk price shock impact on wholesale prices for each of the four chains. The interpretation of the results is the same for each chain and the actual results are quite similar so we discuss only Stop & Shop. The cost pass through rate (CPTR) for a farm milk price shock to the wholesale price is 0.91, which is significantly different from the 0.5 value that would occur if Stop & Shop and its processor enjoyed a monopoly position at retail. However, unique cost shock to the firm that processes Stop & Shop's milk generates a 0.57 CPTR to the wholesale price. It is not statistically different from the monopoly value of 0.5. The spread between the firm specific and industry wide CPTR is due to two of these cross price shocks being significantly different from zero. Clearly there is vertical strategic price interdependence in this industry. A firm specific cost shock to Stop & Shop processor not only increases its wholesale price. The Stop & Shop retail price increases demand for other supermarket's milk shifts out and equilibrium wholesale prices for other processors increase. A ten cent increase in Stop & Shop and Shaw's processors firm specific marginal cost leads to a 1.4 cent increase in the wholesale price that Shaw's pays (significant at the 1% level). The same increase leads to a 1.6 cent (5% level significance) increase in the wholesale price paid by DeMoulas.

The second column in Table-6 gives the cost pass through rates from the wholesale level to the retail level for chain. For each chain the impact of a change in its own price is near the retail monopoly value of 0.5. For example Stop & Shop's value of 0.56 is not significantly different from 0.5. These estimates of how retail price reacts to a wholesale price change also are consistent with the assumed reaction parameters in the Stackelberg model and are not consistent with the unitary values assumed in the vertical Nash model.

Nonetheless these supermarkets are not retail monopolies. There is strategic interaction among supermarkets because changes in the wholesale prices of other firms also affect a firm's retail prices. For example a 10 cent increase in Shaw's wholesale price leads to a significant (at the 1% level) 1.86 cent increase in the Stop & Shop price. This price increase occurs at Stop & Shop because Shaw's retail price increases and Shaw's is a substitute in the Stop & Shop demand equation, so the Stop & Shop, demand curve shifts out and the profit maximizing price, given no change in Stop & Shops marginal cost, increases.

The last column in Table-6 gives the total CPTR which is the combination of the two prior columns. Note that Stop & Shop passes on 86.9% of any change in the farm milk price. The other firms have similar rates. Given that we detected no visible relation between these price series in Graph-I and II except around the NEDC price change this relatively high level of pass through is quite surprising.

The CPTR for firm specific cost shocks are dramatically lower, but not near zero, as we would expect in an effectively competitive market. These rates are lower than industry rates due to significant cross firm interaction and non zero cross firm pass through rates. For example Stop & Shop own firm specific CPTR is 0.36. Nonetheless competition is not so strong that it completely prevents pass through of firm specific cost shocks.

If we compare the results in Table-6 to the full coordination results in Appendix Table A3 one observes that all CPTR in the full coordination game are generally higher than in the vertical Stackelberg game. For example Stop & Shop CPTR for a farm milk price shock increases from 0.869 in Stackelberg to 0.978 under full coordination. Stop & Shop's own firm shock CPTR increases from 0.36 in Stackelberg to 0.60 under full coordination. Although we do not test for it, there seems to be a significant amount of double marginalization (Spengler 1950) that is eliminated when one moves to vertical integration.

Finally we tested to determine whether the total CPTR for a change in the farm milk price are significantly different across the 4 supermarket chains. They are not. This means that these supermarket chains effectively follow the same vertical pricing strategy, however it does not suggest that one should necessarily move to aggregate market level analysis of supermarket level data. To do so would lose the rich detail of firm level strategic interaction and the analysis of how firm specific cost changes, possibly from a merger, influence wholesale and retail market prices.

Summary:

In this paper, using a simplified linear model we demonstrate how to measure, decompose, and test cost pass-through rates using a structural model and explicit strategic games. This is the first research effort to introduce the concept of cross CPTRs in empirical industrial organization. They play an important role in explaining the difference between an industry wide and firm specific cost pass through rate. The latter is always lower when there are positive cross firm CPTRs.

Our estimate of the total pass-through rates in the case of a farm milk price increase for four supermarket chains in Boston average greater than 80 percent. We find that the pass-through rates due to changes in firm specific cost are less than half this magnitude. All own and cross cost shocks are positive and most are significantly different from zero. This latter point implies followship price behavior between firms that is conducive to overall market price elevation.

Our empirical results for different games indicates that the total pass-through rate does not vary much across strategic specifications. In this paper we discuss vertical Stackelberg game because this model fits best in a very weak sense. Since the results for the vertical Stackelberg game fit somewhat better than from the vertically integrated game there does appear however to be some double marginalization, i.e. less than perfect coordination in the market channel.

Finally our model is a symmetric model that does not capture variation in cost pass through rates over time and for increasing as opposed to decreasing farm milk prices. Our graphical analysis clearly establishes that there are important features of this market channel. Future research needs to specify flexible demand and cost specifications to capture richer patterns of CPTRs. One also needs to disaggregate the product from “milk” towards brand level analysis so that one can more accurately model the vertical relationships between processors and retailers.

Reference:

1. Ashenfelter, O., D. Ashmore, J. B. Baker and S-M. Mckernan., “Identifying the Firm-Specific Pass-Through Rate”. FTC Bureau of Economics Working Paper No. 217, January 1998.

2. Baker, Jonathan B., and Bresnahan, Timothy F. “Estimating the Residual Demand Curve Facing a Single Firm.” *International Journal of Industrial Organization.* 6(3) 1988: 283-300.

3. Baker, Jonathan B., and Bresnahan, Timothy F., “The Gains from Merger or Collusion in Product-Differentiated Industries.” *Oligopoly, Competition and Welfare.* Geroski, P. A., Phlips, L., and Ulph, A.,eds. pp 59-76O. Oxford and New York: Blackwell in cooperation with the Journal of Industrial Economics, 1985.

4. Choi, S.C. (1991), “Price Competition in a Channel Structure with a Common Retailer”. *Marketing Science;*, Vol. 10: 4, Pages: 271-296.

5. Chua, J.D., “Explaining Tax Overshifting: Lessons from the Beer Industry”. Mimeo - Department of Economics, Harvard University, March 1999.

6. Cotterill, Ronald W., “Scanner Data: New Opportunities for Demand and Competitive Strategy Analysis.” *Agricultural and Resource Economics Review*. 23(2) 1994: 125-39.

7. Cotterill, Ronald W., Putsis, William P. Jr., and Dhar, ravi., “Assessing the Competitive Interaction Between Private Labels and National Brands.” *Journal of Business*. 73(1) 2000: 109-137.

8. Gardner, Bruce L. (1975), “The Farm-Retail Price Spread in a Competitive Food Industry”.*American Journal of Agricultural Economics;* Vol. 57: 3. Pages: 399-409.

9. Gasmi, Farid., Vuong, Quang H., “An Econometric Analysis of Some Duopolistic Games in Prices and Advertising.” Rhodes, George F. Jr., ed. Econometric methods and models for industrial organizations. Advances in Econometrics, vol. 9, Greenwich, Conn. and London: JAI Press, 1991, pages 225-54.

10. Harris, R. G., and L. A. Sullivan. (1979), “Passing on the Monopoly Overcharge: A Comprehensive Policy Analysis.” *University of Pennsylvania Law Review*; Vol. 128: 2. Pages: 269-360.

11. Heien D.M. (1980), “Markup Pricing in a Dynamic Model of the Food Industry.” *American Journal of Agricultural Economics*; Vol. 62: 1. Pages: 10-18.

12. Jeuland, A. and S. Shugan (1988), “Channel of Distribution Profits When Channel Members Form Conjectures: Note”. *Marketing Science;* Vol. 7: 2. Pages: 202 - 210.

13. Judge G.G., Carter Hill R., Griffiths W.E., And Lee T-C., “Introduction to the Theory and Practice of Econometrics – Second Edition.” John Wiley & Sons, New York: 1988.

14. Kadiyali, V., Vilcassim, N.J., and Chintagunta, P., “Empirical Analysis of Competitive Product Line Pricing Decisions: Lead, Follow, or Move Together. Journal of Business. 69(4): 459-87.

15. Kadiyali, V., Vilcassim, N.J., and Chintagunta, P., “Manufacturer Retailer Interactions and Implications for Channel Power: An Empirical Investigation of Pricing of Analgesics in a Local market.” Unpublished Manuscript. 1998: Ithaca, N.Y.: Cornell University, Johnson Graduate School of Management.

16. Kinnucan H.W. and Forker O.D. (1987), “symmetry in Farm-Retail Price Transmission for Major Dairy Products”. *American Journal of Agricultural Economics;* Vol. 69: 2. Pages: 285-292.

17. McCorriston, S.; Morgan, C. W.; Rayner, A. J. 1998, “Processing Technology, Market Power and Price Transmission”. *Journal of Agricultural Economics;* Vol. 49: 2. Pages: 185-201.

18. Schelling, Thomas C. *The Strategy of Conflict* Harvard University Press, 1960.

19. Slade, M.E., "Productv Rivalry with Multiple Strategic Weapons: An Analysis of Price and Advertising Competition." *Journal of Economics and Management Strategy*. 4(30) 1995: 445-76.

20. Vuong, Quang-H. "Likelihood Ratio Tests for Model Selection and Non-nested Hypotheses." *Econometrica*; 57(2), 1989: 307-33.

Table-1 (a) Input Cost to Wholesale and Wholesale to Retail Cost Pass Through Rates: Two Processors and Two Retailers

Cost Pass Trough Rates		Vertical Nash	Value if, Retail Monopolies a_2 and $b_1 = 0$	Vertical Stackelberg	Value if, Retail Monopolies a_2 and $b_1 = 0$
Effect of Change in the Farm Milk Price Increase on the Wholesale Price of Processor 1.	$\left.\frac{dw_1}{dm}\right\vert_{dm_1=dm_2=0}$	$\frac{6a_1b_2 - 2a_2b_1 - a_2b_2}{9a_1b_2 - 4a_2b_1}$	$\frac{2}{3}$	$\frac{-2a_2b_2 - 3a_2b_1 + 8a_1b_2}{16a_1b_2 - 9a_2b_1}$	$\frac{1}{2}$
Effect of Change in the Farm Milk Price Increase on the Wholesale Price of Processor 2.	$\left.\frac{dw_2}{dm}\right\vert_{dm_1=dm_2=0}$	$\frac{6a_1b_2 - 2a_2b_1 - a_1b_1}{9a_1b_2 - 4a_2b_1}$	$\frac{2}{3}$	$\frac{-2a_1b_1 - 3a_2b_1 + 8a_1b_2}{16a_1b_2 - 9a_2b_1}$	$\frac{1}{2}$
Effect of Change in the Firm Specific Cost of Processor 1 on the Wholesale Price of Processor 1.	$\left.\frac{dw_1}{dm_1}\right\vert_{dm=dm_2=0}$	$\frac{6a_1b_2 - 2a_2b_1}{9a_1b_2 - 4a_2b_1}$	$\frac{2}{3}$	$\frac{8a_1b_2 - 3a_2b_1}{16a_1b_2 - 9a_2b_1}$	$\frac{1}{2}$
Effect of Change in the Firm Specific Cost of Processor 1 on the Wholesale Price of Processor 2.	$\left.\frac{dw_2}{dm_1}\right\vert_{dm=dm_2=0}$	$\frac{-a_1b_1}{9a_1b_2 - 4a_2b_1}$	0	$\frac{-2a_1b_1}{16a_1b_2 - 9a_2b_1}$	0
Effect of Change in the Firm Specific Cost of Processor 2 on the Wholesale Price of Processor 1.	$\left.\frac{dw_1}{dm_2}\right\vert_{dm=dm_1=0}$	$\frac{-a_2b_2}{9a_1b_2 - 4a_2b_1}$	0	$\frac{-2a_2b_2}{16a_1b_2 - 9a_2b_1}$	0
Effect of Change in the Firm Specific Cost of Processor 2 on the Wholesale Price of Processor 2.	$\left.\frac{dw_2}{dm_2}\right\vert_{dm=dm_1=0}$	$\frac{6a_1b_2 - 2a_2b_1}{9a_1b_2 - 4a_2b_1}$	$\frac{2}{3}$	$\frac{8a_1b_2 - 3a_2b_1}{16a_1b_2 - 9a_2b_1}$	$\frac{1}{2}$
Effect of Change in the Wholesale Price of Retailer 1 on the Retail Price of Retailer 1.	$\left.\frac{dp_1}{dw_1}\right\vert_{dw_2=0}$	$\frac{2a_1b_2}{4a_1b_2 - a_2b_1}$	$\frac{1}{2}$	$\frac{2a_1b_2}{4a_1b_2 - a_2b_1}$	$\frac{1}{2}$
Effect of Change in the Wholesale Price of Retailer 1 on the Retail Price of Retailer 2.	$\left.\frac{dp_2}{dw_1}\right\vert_{dw_2=0}$	$\frac{-a_1b_1}{4a_1b_2 - a_2b_1}$	0	$\frac{-a_1b_1}{4a_1b_2 - a_2b_1}$	0
Effect of Change in the Wholesale Price of Retailer 2 on the Retail Price of Retailer 1.	$\left.\frac{dp_1}{dw_2}\right\vert_{dw_1=0}$	$\frac{-a_2b_2}{4a_1b_2 - a_2b_1}$	0	$\frac{-a_2b_2}{4a_1b_2 - a_2b_1}$	0
Effect of Change in the Wholesale Price of Retailer 2 on the Retail Price of Retailer 2.	$\left.\frac{dp_2}{dw_2}\right\vert_{dw_1=0}$	$\frac{2a_1b_2}{4a_1b_2 - a_2b_1}$	$\frac{1}{2}$	$\frac{2a_1b_2}{4a_1b_2 - a_2b_1}$	$\frac{1}{2}$

Table – 1 (b): CPTR Equations For Two Processors and Two Retailers (Total):

Total Cost Pass Through Rates		Vertical Nash	Value if, Retail Monopolies a_2 and $b_1 = 0$	Vertical Stackelberg	Value if, Retail Monopolies a_2 and $b_1 = 0$	Vertical Coordination	Value if, Retail Monopolies a_2 and $b_1 = 0$
Effect of Milk Price Change on Retail Price of 1	$\frac{dp_1}{dm}$	$\frac{(3a_1 - 2a_2)b_2}{9a_1b_2 - 4a_2b_1}$	$\frac{1}{3}$	$\frac{(4a_1 - 3a_2)b_2}{16a_1b_2 - 9a_2b_1}$	$\frac{1}{4}$	$\frac{b_2(2a_1 - a_2)}{4a_1b_2 - a_2b_1}$	$\frac{1}{2}$
Effect of Milk Price Change on Retail Price of 1	$\frac{dp_2}{dm}$	$\frac{(3b_2 - 2b_1)a_1}{9a_1b_2 - 4a_2b_1}$	$\frac{1}{3}$	$\frac{(4b_2 - 3b_1)a_1}{16a_1b_2 - 9a_2b_1}$	$\frac{1}{4}$	$\frac{a_1(2b_2 - b_1)}{4a_1b_2 - a_2b_1}$	$\frac{1}{2}$
Effect of Firm 1 Specific Cost Change on Retail Price 1	$\frac{dp_1}{dm_1}$	$\frac{3a_1b_2}{9a_1b_2 - 4a_2b_1}$	$\frac{1}{3}$	$\frac{4a_1b_2}{16a_1b_2 - 9a_2b_1}$	$\frac{1}{4}$	$\frac{2a_1b_2}{4a_1b_2 - a_2b_1}$	$\frac{1}{2}$
Effect of Firm 1 Specific Cost Change on Retail Price 2	$\frac{dp_2}{dm_1}$	$\frac{-2a_1b_1}{9a_1b_2 - 4a_2b_1}$	0	$\frac{-3a_1b_1}{16a_1b_2 - 9a_2b_1}$	0	$\frac{-a_1b_1}{4a_1b_2 - a_2b_1}$	0
Effect of Firm 2 Specific Cost Change on Retail Price 1	$\frac{dp_1}{dm_2}$	$\frac{-2a_2b_2}{9a_1b_2 - 4a_2b_1}$	0	$\frac{-3a_2b_2}{16a_1b_2 - 9a_2b_1}$	0	$\frac{-a_2b_2}{4a_1b_2 - a_2b_1}$	0
Effect of Firm 2 Specific Cost Change on Retail Price 2	$\frac{dp_2}{dm_2}$	$\frac{3a_1b_2}{9a_1b_2 - 4a_2b_1}$	$\frac{1}{3}$	$\frac{4a_1b_2}{16a_1b_2 - 9a_2b_1}$	$\frac{1}{4}$	$\frac{2a_1b_2}{4a_1b_2 - a_2b_1}$	$\frac{1}{2}$

<u>Table-2: Retail Price Increases Observed the Month After the NEDC Farm Level Price Increase</u>

	Milk Price Before and After the NEDC		Change in Milk Price Before and After the NEDC	
	Month Before NEDC	Month After NEDC	$ Change	% Change
Farm Level Milk Price	1.36	1.46	0.10	0.073
Stop & Shop	2.52	2.66	0.14	0.056
Shaw's	2.48	2.64	0.16	0.064
Star Market	2.65	2.79	0.14	0.053
DeMoulas	2.27	2.41	0.14	0.062

Table 3: Test Statistic for Model Selection:

Models	Test Statistic
Vertical Nash vs. Stackleberg*	-0.3712239149
Vertical nash* vs. Coordination	0.1572588124
Coordination vs. Stackleberg*	-0.2250821273

† Asterisk implies given the sign of the test statistic the model is more appropriate.

Table-4: Descriptive Statistics of the Variables

	Mean	Std. Deviation	Minimum	Maximum
Variable: Price per 1000 Gallon				
Stop & Shop	2553.00	117.5	2367.2	2701.00
Shaw's	2504.7	88.8	2355.00	2667.7
Star Market	2683.5	115.84	2526.00	2846.9
Demoulas	2310.00	100.187	2198.5	2457.57
Farm Milk Price	1471.1	68.921	1353.9	1667.00
Variable: Quantity Sold ('000 gallon)				
Stop & Shop	1214.4	69.653	1085.8	1381.2
Shaw's	988.71	42.760	906.67	1063.6
Star Market	623.69	29.781	573.23	681.68
Demoulas	867.42	37.959	793.45	945.77
Variable: Weighted Average % Price Reduction (Any Price Reduction)				
Stop & Shop	11.93	4.07	7.14	20.18
Shaw's	14.19	3.29	7.20	22.15
Star Market	9.37	3.06	5.80	17.55
Demoulas	12.18	4.96	7.06	29.00
Variable: Volume per unit (Gallon per unit sold)				
Stop & Shop	0.68755	0.0069817	0.67411	0.69872
Shaw's	0.71743	0.0067679	0.70369	0.72651
Star Market	0.65251	0.0071587	0.64025	0.66802
Demoulas	0.73722	0.0061670	0.72546	0.74767

Table 5: Estimation Results - from Manufacturer Stackelberg Game

Varibale Name	Estimate	Standard Error	Asymptotic t-statistic
Demand Parameters for Stop & Shop			
Intercept I1	2921.6	2161.7	1.3515
Own Price A1	-8.5426	2.2335	-3.8248
Shaw's Price A2	4.674	1.8255	2.5604
Star Market Price A3	-0.46104	3.2987	-0.13976
DeMoulas Price A4	4.1645	3.2328	1.2882
Weighted Average % Price Reduction A5	1.7295	14.187	0.12191
Demand Parameters for Shaw's			
Intercept I2	2375.2	1726	1.3761
Stop & Shop Price B1	1.7408	3.0869	0.56394
Own Price B2	-10.564	1.8576	-5.687
Star Market Price B3	1.9783	2.5278	0.78261
DeMoulas Price B4	6.5756	2.432	2.7038
Weighted Average % Price Reduction B5	9.4285	6.3897	1.4756
Demand Parameters for Star Market			
Intercept I3	5273.5	1154.4	4.5683
Stop & Shop Price C1	3.6875	1.5839	2.3281
Shaw's Price C2	3.4513	1.0074	3.4259
Own Price C3	-11.705	1.7579	-6.6584
DeMoulas Price C4	3.7733	1.8633	2.0251
Weighted Average % Price Reduction C5	-1.7281	5.5946	-0.30889
Demand Parameters for DeMoulas			
Intercpet I4	1327.4	1292.5	1.027
Stop & Shop Price D1	4.2862	2.5793	1.6618
Shaw's Price D2	3.331	1.4227	2.3413
Star Market Price D3	1.8831	2.5018	0.7527
Own Price D4	-10.727	1.9957	-5.3752
Weighted Average % Price Reduction D5	-2.3334	5.1545	-0.4527
Cost Parameters Stop & Shop			
Intercpet CI1	1589.3	374.52	4.2435
Voume Per Unit M1	-1356.8	631.63	-2.1481
Cost Parameters for Shaw's			
Intercept CI2	1490	315.83	4.7176
Volume Per Unit M2	-1027	449.47	-2.285
Cost Parameters for Star Market			
Intercept CI3	1127.5	243.25	4.6353
Volume Per Unit M3	-114.48	234.33	-0.48854
Cost Parameters for DeMoulas			
Intercept CI4	1297.4	316.16	4.1036
Volume Per Unit M4	-951.33	441.71	-2.1537

LOG-LIKELIHOOD FUNCTION= -145.69428

Table 6: Cost Pass Through (CPTR) Table - Vertical Stackelberg Game

Input Cost to Whole Sale Price:		**CPTR**
Change in the Wholesale Price of Stop & Shop		
Milk Price Shock H_0: CPTR = 0.5		0.91267 (***)
Unobservable Shock	Own H_0: CPTR = 0.5	0.57411
	Cross Shock from: Shaw's Processor	0.14379 (***)
	Cross Shock from: Star market's Processor	0.031892
	Cross Shock from: DeMoulas's Processor	0.16287 (**)
Change in the Wholesale Price of Shaw's		
Milk Price Shock H_0: CPTR = 0.5		0.90638 (***)
Unobservable Shock	Own H_0: CPTR = 0.5	0.58988 (***)
	Cross Shock from: Stop & Shop's Processor	0.094725
	Cross Shock from: Star Market's Processor	0.054252
	Cross Shock from: DeMoulas's Processor	0.16752 (**)
Change in the Wholesale Price of Star Market		
Milk Price Shock H_0: CPTR = 0.5		0.89608 (***)
Unobservable Shock	Own H_0: CPTR = 0.5	0.5312
	Cross Shock from: Stop & Shop's Processor	0.10393 (***)
	Cross Shock from: Shaw's Processor	0.11938 (***)
	Cross Shock from: DeMoulas's Processor	0.14157 (***)
Change in the Wholesale Price of DeMoulas		
Milk Price Shock H_0: CPTR = 0.5		0.88116 (***)
Unobservable Shock	Own H_0: CPTR = 0.5	0.60646 (**)
	Cross Shock from: Stop & Shop's Processor	0.1079 (**)
	Cross Shock from: Shaw's Processor	0.11855 (***)
	Cross Shock from: Star Market's Processor	0.048242

Wholesale price to Retail Price:	**CPTR**
Change in the Retail Price of Stop & Shop	
Own H_0: CPTR = 0.5	0.5578
Cross Shock from: Shaw's Wholesale Price Change	0.18609 (***)
Cross Shock from: Star Markets' Wholesale Price Change	0.019667
Cross Shock from: DeMoulas' Wholesale Price Change	0.19705
Change in the Retail Price of Shaw's	
Own H_0: CPTR = 0.5	0.5709 (***)
Cross Shock from: Stop & Shop's Wholesale Price Change	0.10061
Cross Shock from: Star Market's Wholesale Price Change	0.069469
Cross Shock from: DeMoulas's Wholesale Price Change	0.2134 (***)
Change in the Retail Price of Star Market	
Own H_0: CPTR = 0.5	0.52311
Cross Shock from: Stop & Shop's Wholesale Price Change	0.12495 (***)
Cross Shock from: Shaw's Wholesale Price Change	0.13568 (***)
Cross Shock from: DeMoulas's Wholesale Price Change	0.157 (***)
Change in the Retail Price of DeMoulas	
Own H_0: CPTR = 0.5	0.58628 (**)
Cross Shock from: Stop & Shop's Wholesale Price Change	0.13803 (**)
Cross Shock from: Shaws' Wholesale Price Change	0.13772 (***)
Cross Shock from: Star Market's Wholesale Price Change	0.048242

(***) Significant at 1% Level (Wald Chi-Square Statistic)
(**) Significant at 5% Level (Wald Chi-Square Statistic)

Total:		**CPTR**
Stop & Shop		
Milk Price H_0: CPTR = 1.00		0.869
Unobservable Shock	Own H_0: CPTR = 0.25	0.36117 (**)
	From Shaw's: Processor	0.21568 (***)
	From Star Market's: Processor	0.047838
	From DeMoulas's Processor	0.244310 (**)
Shaw's		
Milk Price Shock H0: CPTR = 1.00		0.85956
Unobservable Shock	Own H_0: CPTR = 0.25	0.38482 (***)
	From Stop & Shop's: Processor	0.14209
	From Star Market's: Processor	0.081378
	From DeMoulas's Processor	0.25127 (**)
Star Market		
Milk Price Shock H0: CPTR = 1.00		0.8441 (**)
Unobservable Shock	Own H_0: CPTR = 0.25	0.2968 (**)
	From Stop & Shop's: Processor	0.1559 (***)
	From Shaw's: Processor	0.17907 (***)
	From DeMoulas's Processor	0.21235 (***)
DeMoulas		
Milk Price H0: CPTR = 1.00		0.82173 (**)
Unobservable Shock	Own H_0: CPTR = 0.25	0.40969
	From Stop & Shop's: Processor	0.16185 (**)
	From Shaw's: Processor	0.17783 (***)
	From Star Market's Processor	0.072363

Table Table A-1: Estimation Results - from Full Coordination Game

Varibale Name	Estimate	Standard Error	Asymptotic t-statistic
Demand Parameters for Stop & Shop			
Intercept I1	299.78	1375.3	0.21797
Own Price A1	-11.122	2.4752	-4.4933
Shaw's Price A2	3.8362	1.3672	2.8058
Star Market Price A3	6.4452	1.9803	3.2546
DeMoulas Price A4	1.0821	2.5457	0.42505
Weighted Average % Price Reduction A5	-7.2902	7.3313	-0.9944
Demand Parameters for Shaw's			
Intercept I2	4536.9	1443.7	3.1426
Stop & Shop Price B1	7.5111	2.6835	2.7991
Own Price B2	-13.485	1.6286	-8.2801
Star Market Price B3	0.37765	2.3545	0.16039
DeMoulas Price B4	4.3224	2.2358	1.9333
Weighted Average % Price Reduction B5	3.5587	2.7851	1.2777
Demand Parameters for Star Market			
Intercept I3	6037.7	1095.2	5.5128
Stop & Shop Price C1	6.2784	1.4871	4.2219
Shaw's Price C2	2.996	0.89372	3.3522
Own Price C3	-13.703	1.4171	-9.6696
DeMoulas Price C4	3.3731	1.4603	2.3098
Weighted Average % Price Reduction C5	3.1759	2.8702	1.1065
Demand Parameters for DeMoulas			
Intercept I4	1786.7	1213.1	1.4728
Stop & Shop Price D1	7.9764	2.3613	3.3779
Shaw's Price D2	2.3087	1.393	1.6574
Star Market Price D3	0.41268	2.1855	0.18882
Own Price D4	-12.205	1.9436	-6.2796
Weighted Average % Price Reduction D5	0.63037	2.5224	0.24991
Cost Parameters Stop & Shop			
Intercpet CI1	1394.9	254.02	5.4913
Voume Per Unit M1	-612.64	273.16	-2.2427
Cost Parameters for Shaw's			
Intercept CI2	1170.3	201.01	5.8221
Volume Per Unit M2	-292.29	173.18	-1.6877
Cost Parameters for Star Market			
Intercept CI3	1150.9	214.57	5.3637
Volume Per Unit M3	24.952	125.85	0.19827
Cost Parameters for DeMoulas			
Intercept CI4	1016.8	187.86	5.4126
Volume Per Unit M4	-338.12	191	-1.7703

LOG-LIKELIHOOD FUNCTION= -149.55106

Table A-2: Estimation Results - from Vertical Nash Game

Varibale Name	Estimate	Standard Error	Asymptotic t-statistic
Demand Parameters for Stop & Shop			
Intercept I1	3821.2	1836.1	2.0812
Own Price A1	-8.3838	2.3441	-3.5766
Shaw's Price A2	4.1382	1.663	2.4885
Star Market Price A3	-0.41235	2.9368	-0.14041
DeMoulas Price A4	4.1239	2.9424	1.4015
Weighted Average % Price Reduction A5	1.7278	11.412	0.1514
Demand Parameters for Shaw's			
Intercept I2	2979.4	1586.6	1.8779
Stop & Shop Price B1	3.1348	2.6264	1.1936
Own Price B2	-11.273	1.71	-6.5922
Star Market Price B3	1.3147	2.3685	0.55507
DeMoulas Price B4	6.3302	2.2869	2.768
Weighted Average % Price Reduction B5	6.4964	4.4948	1.4453
Demand Parameters for Star Market			
Intercept I3	5478.1	1083.7	5.055
Stop & Shop Price C1	4.0715	1.3168	3.092
Shaw's Price C2	3.6041	0.8464	4.2582
Own Price C3	-12.552	1.4153	-8.8684
DeMoulas Price C4	4.0772	1.5381	2.6508
Weighted Average % Price Reduction C5	-1.2668	4.394	-0.28831
Demand Parameters for DeMoulas			
Intercept I4	1126.8	1244.3	0.90557
Stop & Shop Price D1	4.8495	2.2235	2.181
Shaw's Price D2	3.4372	1.3452	2.5551
Star Market Price D3	1.3307	2.2506	0.59126
Own Price D4	-10.744	1.9095	-5.6263
Weighted Average % Price Reduction D5	-0.99436	3.8297	-0.25964
Cost Parameters Stop & Shop			
Intercpet CI1	1455	296.76	4.9029
Voume Per Unit M1	-962.58	454.35	-2.1186
Cost Parameters for Shaw's			
Intercept CI2	1360.8	245.51	5.5425
Volume Per Unit M2	-700.08	298.32	-2.3468
Cost Parameters for Star Market			
Intercept CI3	1152.6	224.04	5.1446
Volume Per Unit M3	-60.184	177.87	-0.33836
Cost Parameters for DeMoulas			
Intercept CI4	1200.4	248.76	4.8256
Volume Per Unit M4	-709.78	320.09	-2.2174

LOG-LIKELIHOOD FUNCTION= -146.99888

Table A-3: Cost Pass Through (CPTR) Table - Full Coordination Game

Total:		CPTR
Stop & Shop		
Milk Price	H_0: CPTR = 1.00	0.97832
Unobservable Shock	Own H_0: CPTR = 0.5	0.60007 (***)
	From Shaw's: Processor	0.12961 (***)
	From Star Market's: Processor	0.176900 (***)
	From DeMoulas's Processor	0.071737
Shaw's		
Milk Price Shock	H_0: CPTR = 1.00	0.9337 (***)
Unobservable Shock	Own H_0: CPTR = 0.5	0.55297 (***)
	From Stop & Shop's: Processor	0.20477 (***)
	From Star Market's: Processor	0.068888
	From DeMoulas's Processor	0.10706 (**)
Star Market		
Milk Price Shock	H_0: CPTR = 1.00	0.93992 (***)
Unobservable Shock	Own H_0: CPTR = 0.5	0.55713 (***)
	From Stop & Shop's: Processor	0.18677 (***)
	From Shaw's: Processor	0.10201 (***)
	From DeMoulas's Processor	0.094007 (***)
DeMoulas		
Milk Price	H_0: CPTR = 1.00	0.92389 (***)
Unobservable Shock	Own H_0: CPTR = 0.5	0.53516 (**)
	From Stop & Shop's: Processor	0.21861 (***)
	From Shaw's: Processor	0.096379 (***)
	From Star Market's Processor	0.073741

(Significant at 1% Level (Wald Chi-Square Statistic)
(Significant at 5% Level (Wald Chi-Square Statistic)

Table A-4: Cost Pass Through (CPTR) Table - Vertical Nash Game

Input Cost to Whole Sale Price:		CPTR
Change in the Wholesale Price of Stop & Shop		
Milk Price Shock		0.93887
	H_0: CPTR = 0.667	(***)
Unobservable Shock	Own H_0: CPTR = 0.667	0.72031 (**)
	Cross Shock from: Shaw's Processor	0.098 (***)
	Cross Shock from: Star market's Processor	0.009562
	Cross Shock from: DeMoulas's Processor	0.111 (**)
Change in the Wholesale Price of Shaw's		
Milk Price Shock		0.94298
	H_0: CPTR = 0.667	(***)
Unobservable Shock	Own H_0: CPTR = 0.667	0.72255 (***)
	Cross Shock from: Stop & Shop's Processor	0.081131 (**)
	Cross Shock from: Star Market's Processor	0.024151
	Cross Shock from: DeMoulas's Processor	0.11515 (***)
Change in the Wholesale Price of Star Market		
Milk Price Shock		0.93937
	H_0: CPTR = 0.667	(***)
Unobservable Shock	Own H_0: CPTR = 0.667	0.67828
	Cross Shock from: Stop & Shop's Processor	0.082755 (***)
	Cross Shock from: Shaw's Processor	0.081923 (***)
	Cross Shock from: DeMoulas's Processor	0.096413 (***)
Change in the Wholesale Price of DeMoulas		
Milk Price Shock		0.92949
	H_0: CPTR = 0.667	(***)
Unobservable Shock	Own H_0: CPTR = 0.667	0.73259 (**)
	Cross Shock from: Stop & Shop's Processor	0.090433 (***)
	Cross Shock from: Shaw's Processor	0.083721 (***)
	Cross Shock from: Star Market's Processor	0.02275

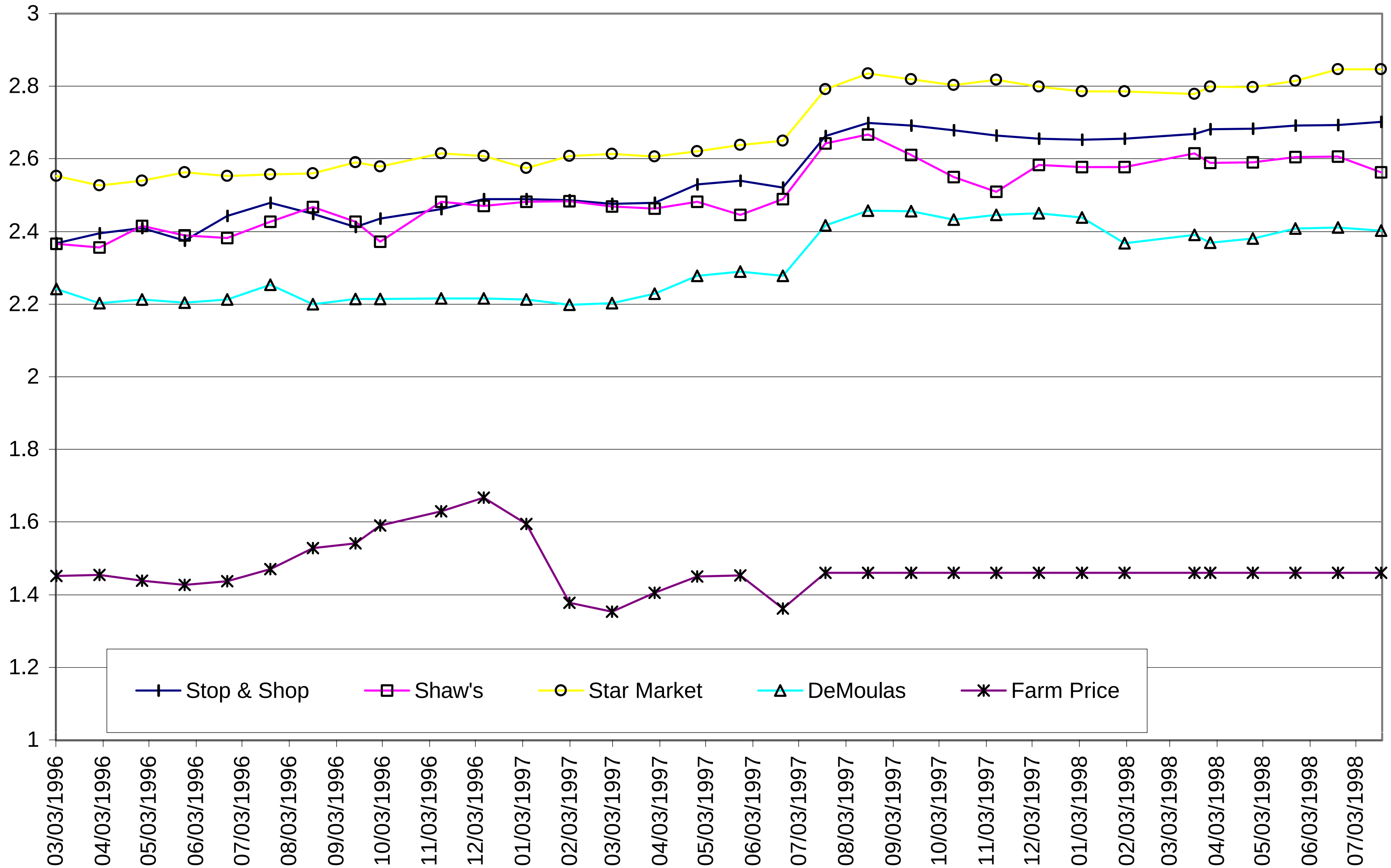
Wholesale price to Retail Price:	CPTR
Change in the Retail Price of Stop & Shop	
Own H_0: CPTR = 0.5	0.56776 (**)
Cross Shock from: Shaw's Wholesale Price Change	0.17147 (***)
Cross Shock from: Star Markets' Wholesale Price Change	0.007744
Cross Shock from: DeMoulas' Wholesale Price Change	0.18904 (**)
Change in the Retail Price of Shaw's	
Own H_0: CPTR = 0.5	0.57033 (***)
Cross Shock from: Stop & Shop's Wholesale Price Change	0.13114 (**)
Cross Shock from: Star Market's Wholesale Price Change	0.042372
Cross Shock from: DeMoulas's Wholesale Price Change	0.19927 (***)
Change in the Retail Price of Star Market	
Own H_0: CPTR = 0.5	0.51389
Cross Shock from: Stop & Shop's Wholesale Price Change	0.1365 (***)
Cross Shock from: Shaw's Wholesale Price Change	0.13212 (***)
Cross Shock from: DeMoulas's Wholesale Price Change	0.15413 (***)
Change in the Retail Price of DeMoulas	
Own H_0: CPTR = 0.5	0.58409 (**)
Cross Shock from: Stop & Shop's Wholesale Price Change	0.15757 (***)
Cross Shock from: Shaws' Wholesale Price Change	0.13811 (***)
Cross Shock from: Star Market's Wholesale Price Change	0.040351 (***)

Total:		CPTR
Stop & Shop		
Milk Price		0.87774
	H_0: CPTR = 1.00	
Unobservable Shock	Own H_0: CPTR = 0.33	0.44061 (**)
	From Shaw's: Processor	0.196 (***)
	From Star Market's: Processor	0.019123
	From DeMoulas's Processor	0.222 (**)
Shaw's		
Milk Price Shock		0.88595
	H_0: CPTR = 1.00	
Unobservable Shock	Own H_0: CPTR = 0.33	0.44509 (***)
	From Stop & Shop's: Processor	0.16226 (**)
	From Star Market's: Processor	0.048302
	From DeMoulas's Processor	0.2303 (***)
Star Market		
Milk Price Shock		0.87875
	H_0: CPTR = 1.00	(**)
Unobservable Shock	Own H_0: CPTR = 0.33	0.35657
	From Stop & Shop's: Processor	0.16551 (***)
	From Shaw's: Processor	0.16385 (***)
	From DeMoulas's Processor	0.19283 (***)
DeMoulas		
Milk Price		0.85899
	H_0: CPTR = 1.00	(**)
Unobservable Shock	Own H_0: CPTR = 0.33	0.46518 (**)
	From Stop & Shop's: Processor	0.18087 (***)
	From Shaw's: Processor	0.16744 (***)
	From Star Market's Processor	0.0455

(***) Significant at 1% Level (Wald Chi-Square Statistic)

(**) Significant at 5% Level (Wald Chi-Square Statistic)

Graph-I: Retail and Farm Milk Price Per Gallon



Graph-II: Retail and Farm Price of Milk (First Differenced)